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Bending Wind Turbine Blades Circular

Environmental & Economic Improvements Through Chemical Recycling

Bending Wind Turbine Blades Circular

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Wind turbine blade waste is becoming an increasing problem as the first generation of turbines is now being decommissioned and the blades are ending up mainly in landfill, incineration and the cement industry. The annual volume of this waste in Europe alone is expected to increase from 40,000 tons to 120,000 tons in the next 10 years. The wind, composite and chemical industries consider it important to improve the circularity of blades, and new innovations in chemical recycling could play a part in that. The goal of Interreg North Sea Region funded project, DecomTools, is to decrease the costs and environmental impact of the decommissioning of offshore wind farms. The chemical recycling of blades is expected to play an important role in meeting those goals. Therefore, Dutch recycling company Virol will be testing it at a pilot scale as part of the project.

Figure 1. Decommissioned blades in the Netherlands (courtesy Nina Vielen-Kallio)

In the coming years approximately 4,700 turbines are estimated to be repowered or decommissioned in Europe [1]. As the decommissioning industry is relatively young, new end-of-life solutions are needed in order to improve the efficiency and environmental impact and to bring the costs down.

DecomTools

The wind, composite and chemical industries are working together in order to find new solutions to increase the circularity of composites [2]. Therefore, Interreg North Sea Region funded project, DecomTools, fits well in the current objectives of these industries. With a total budget of € 4.7 million and 14 partners from the North Sea region, DecomTools seeks to find solutions to improve both the economic and environmental perspectives of the decommissioning of offshore wind farms. With these goals in mind, one of the focus points is to demonstrate the chemical recycling of wind turbine blades at a pilot scale. Naturally, this solution would also be applicable to blades originating from onshore turbines.

Blades Have Changed and Will Continue To Do So

The testing is designed with the future in mind – recycling technology needs to be suitable for the current blade waste but also for the waste coming in 20 years as the blades have changed not only in size but also in composition. In the past, the blades were only manufactured with glass fibre reinforced plastic (GFRP), but as the size of the blades has increased, the manufacturers have started to use carbon fibre reinforced plastic (CFRP) more and more in order to meet the performance requirements. For this reason the technology used in chemical recycling cannot be too dependent on fully homogenous and standard feedstock as blades are a mixture of fibres, epoxy, polyester, balsa wood, polyurethane, metals, etc.

Collaboration with Manufacturers

Because of the differences between compositions of blades and evolution in material use, it was considered important to have different types of blades for testing. The first samples have been received from LM Wind Power and more are expected from TPI Composites. As the testing is done at a pilot scale with a few hundred kilograms per sample, it is important to get a representative sample from the blades. The materials and relative amounts of them are different at the tip of the blade compared with the root. Additionally, the main volume of wind turbine waste is currently not coming from the decommissioning of wind farms but from manufacturing and service [3], which is why the testing was designed to also address manufacturing waste.

Figure 2. Cutting of LM Wind Power blade (courtesy Nina Vielen-Kallio)

Different Focus in Output

So far, when chemical recycling has been tested for composites, the focus has often either been on recovering the fibres as unharmed as possible or manufacturing fuels from the resin. In these cases the challenge has been the cost of the recovered fibres compared with virgin fibres and determining the difference between the incineration route and the manufacturing fuels as both lead to energy generation. In DecomTools the focus is on manufacturing chemicals that are widely used as raw materials. In this way, crude oil can be substituted, leading to real circularity, and waste becomes valuable secondary raw material.

Chemical Recycling Addresses Only One Challenge in the Total Value Chain

The recycling of wind turbine blades has several aspects of which the recycling technology is just one. Other aspects include the economic viability of chemical recycling, which depends, for example, on the regulative framework, which differs by country; costs of the preprocessing requirements, such as cutting and shredding of the blades; and the expected volumes, which might be lower if the turbines end up in second-hand markets, meaning the blades still have another life possibly outside the European Union. Additional to the economic perspective of these, the importance of sustainability is only increasing, which is more complicated to measure and assess objectively. In general, five aspects which need to be assessed for each step taken in any kind of process can be identified: regulative, technological, environmental, economic and social.

Economic Perspective

Currently the gate fee for GFRP waste is on average 150 €/ton for the cement kiln route in Germany, and the cost of mechanical recycling in the Netherlands is between 500 and 1,000 €/ton, which includes preprocessing at the dismantling location and transportation and recycling [4]. In order for chemical recycling to compete with these prices, the value of the output chemicals needs to be high enough to cover the processing costs. It can be expected that the complete value chain requires optimisation. Decisions need to made, for example, between keeping blade pieces relatively large, which saves time at the dismantling site, and using smaller pieces, which decreases the number of transportations. On the one hand, shredding composites is also energy consuming, but smaller particle size can be expected to have a positive impact on reaction time in chemical processing.

Environmental Perspective

The cutting and shredding of blades is not only time and energy consuming, but it can also cause debris and dust that is irritating to humans and not desirable to have at the premises. Therefore the environmental aspect needs to be assessed. Because smaller particle size is desirable for chemical recycling and transportation, it is worth investigating how to cut and shred the blades at the dismantling site (or harbour, when blades originate from an offshore wind farm) without risk to people and the environment. Using water cutting and different types of covers around the shredder are some options to lower the negative impact on the environment.

Enormous Opportunity

The use of GFRP and CFRP blades is growing globally every year due to their light weight, high durability, design flexibility, mechanical properties and ease of manufacturing. Without doubt, these aspects have made it possible to design and manufacture current 10+MW wind turbines, which are providing renewable energy much more efficiently and at a lower price than the first kW-size generation. As many times before, industrial development focuses first on technological breakthrough, then economic viability and then capacity increase together with cost reduction. Most of the time, the end-of-life strategy is not considered at the design table. However, the wind industry is not facing this challenge alone – similar and even greater composite waste volumes are also coming from the maritime and building industries. This translates into a more steady flow of feedstock compared with project-based decommissioning of wind farms. Chemical recycling could be one of the key topics to address the composite waste challenge and convert it into a global opportunity.

Figure 3. Shredded blade material (courtesy Nina Vielen-Kallio)

Further Reading

- Wind Europe. May 2020. Accelerating wind turbine blade circularity.
- Wind Europe. July 2019. New joint project between wind and chemical industry to advance wind turbine recycling.
- Liu, P. and Barlow, C.Y. 2017. Wind turbine blade waste in 2050. Waste Management 62, pp. 229–240. ■

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